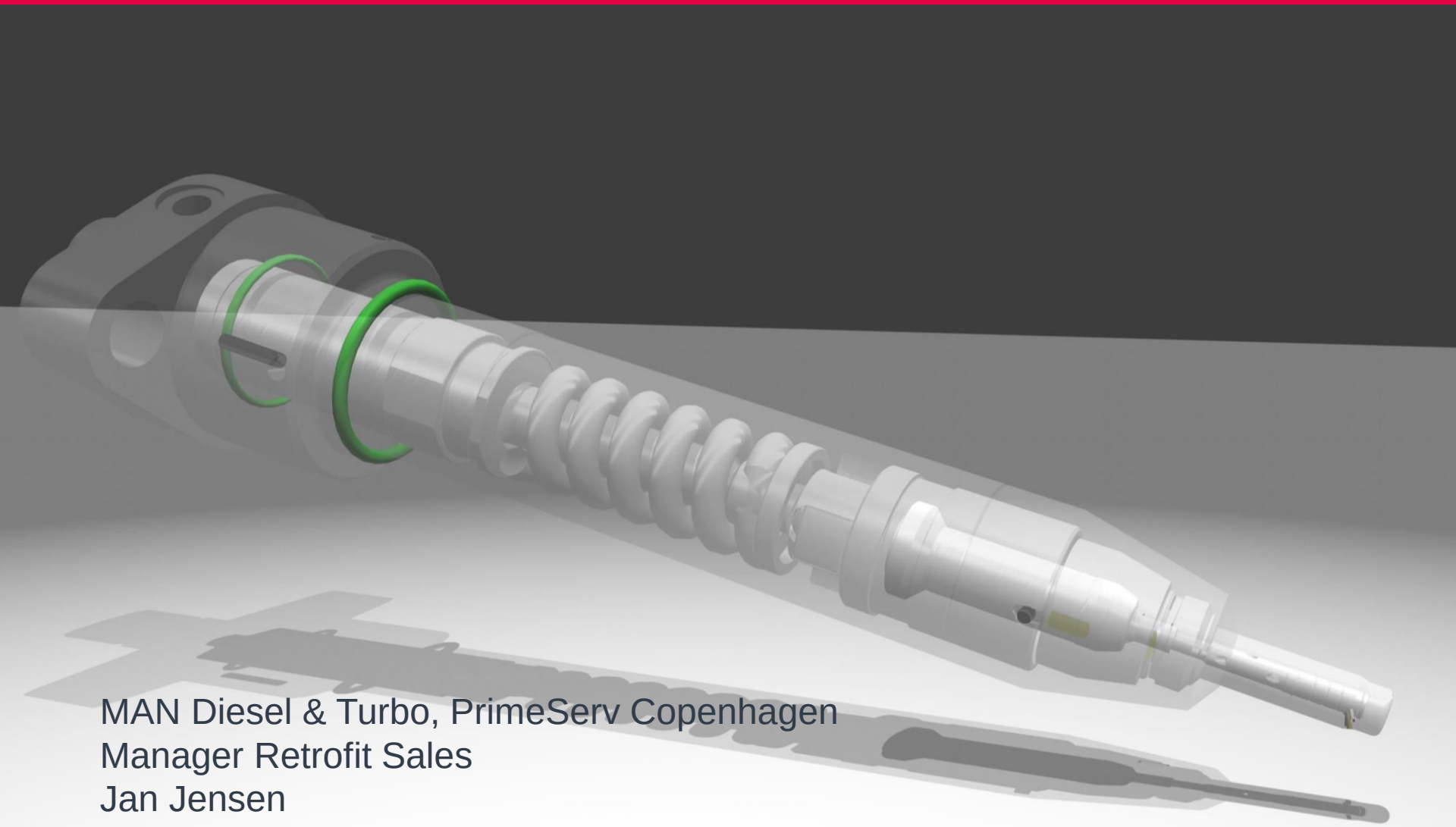
Retrofit: MAN B&W two stroke engine



MAN Diesel & Turbo, PrimeServ Copenhagen
Manager Retrofit Sales
Jan Jensen

Retrofit Products

Retrofit = utilizing the advantage of the modern technology

Two stroke retrofit

Alpha Lub

Slide valves

PMI Auto tuning

Low load tuning

Propeller optimization

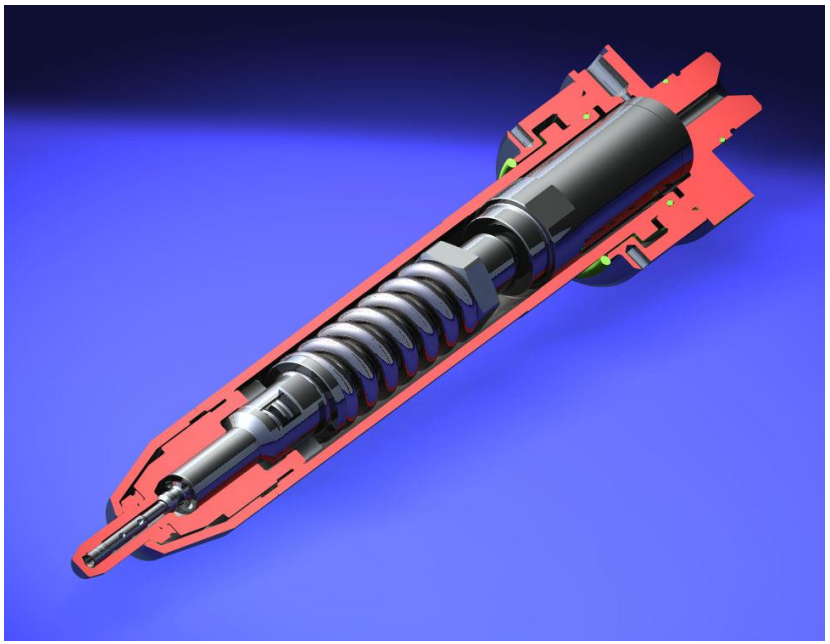
De-rating

Gas conversion ME-GI

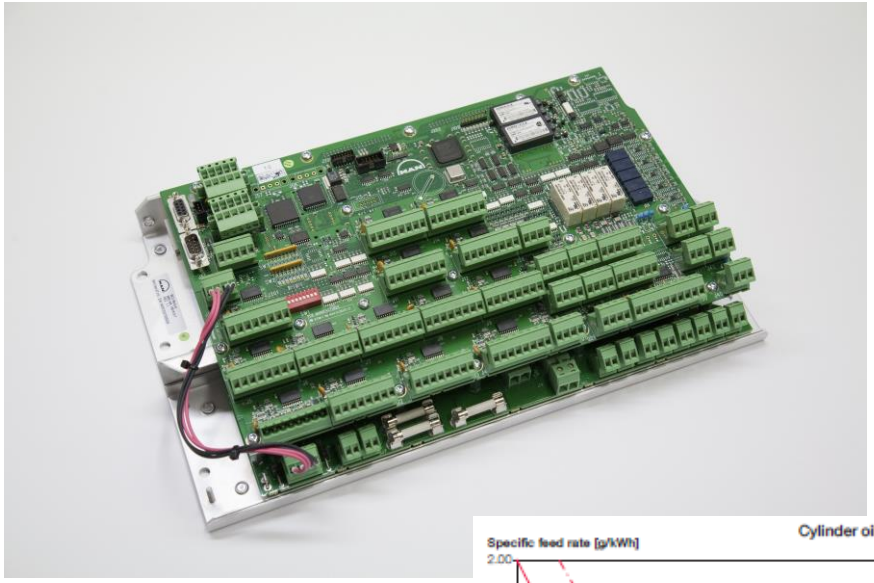
Slow steaming

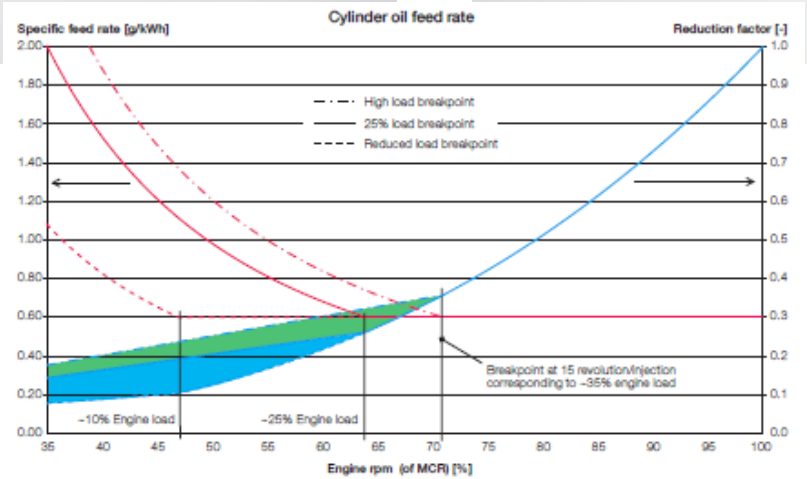
Alpha lubricator

Slide fuel valve



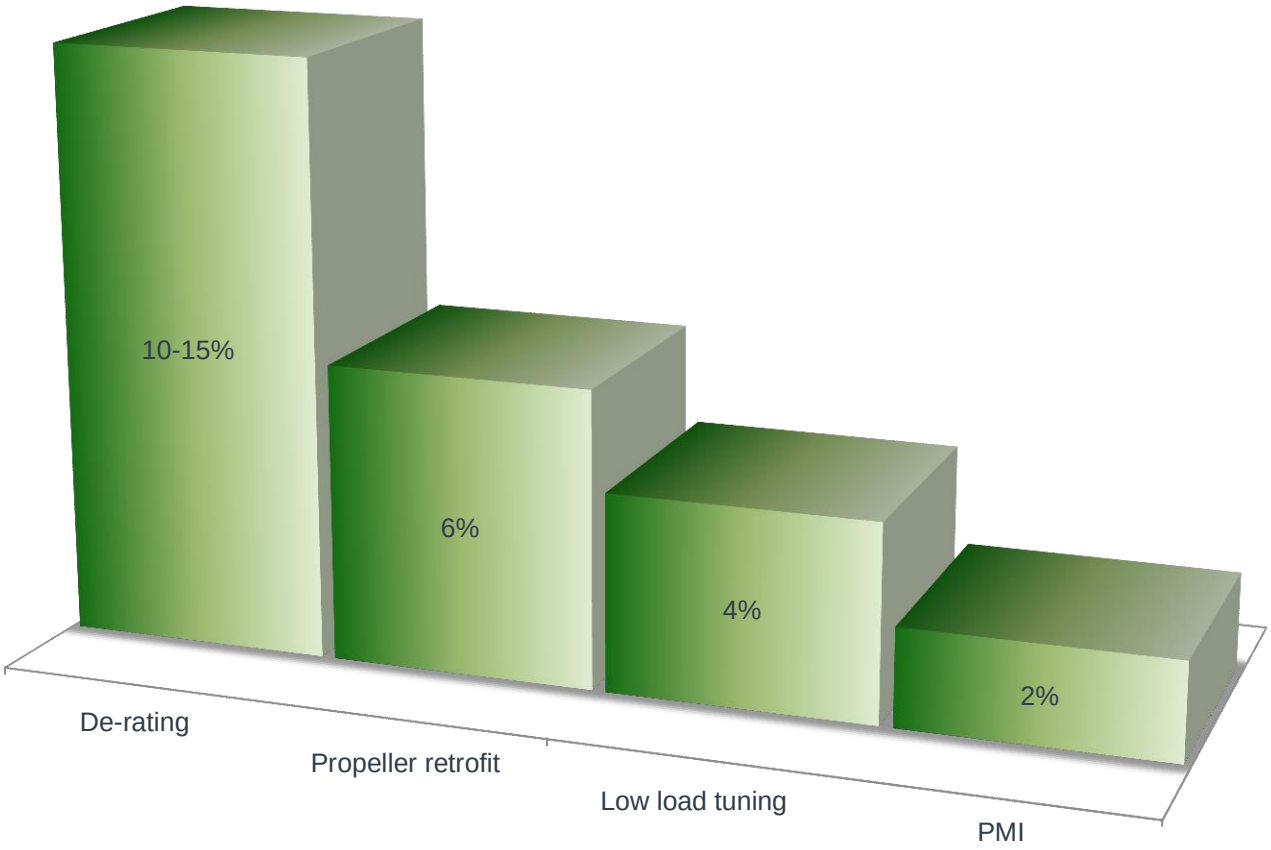
Alpha Lub Upgrade



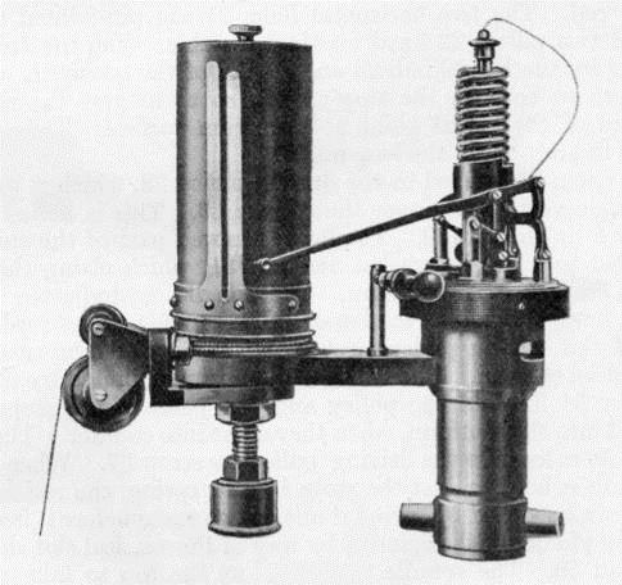


Fuel savings

Fuel Savings



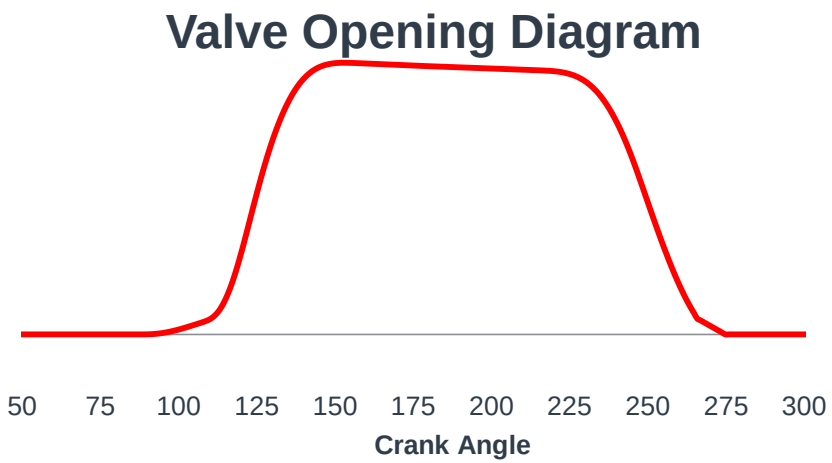
PMI Auto tuning



Low load tuning

- TC cut out
- EGB
- VTA
- Variable exh valve timing

MAN EcoCam



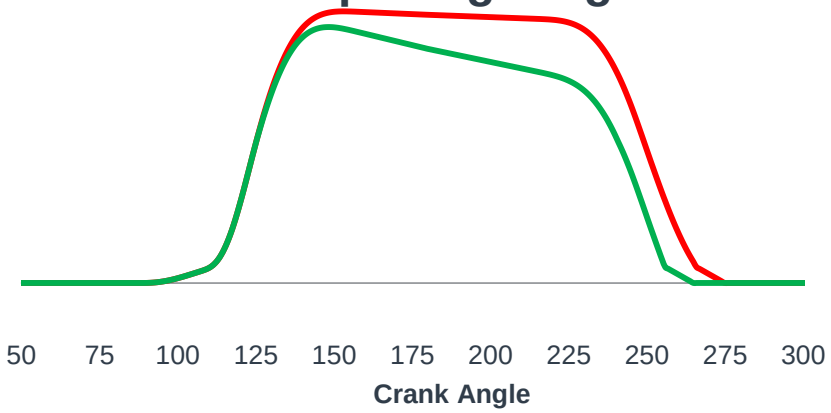
Exhaust valve timing

MAN EcoCam

High load

Low load

Valve Opening Diagram



MAN EcoCam

EcoCam = Fexible exhaust valve timing

Fuel savings 5-6 g/kWh

1. Wave 500 50MC-C engines
2. Wave 1800 60MC-C engines

MAN EcoCam

EcoCam = Fexible exhaust valve timing

Fuel savings 5-6 g/kWh

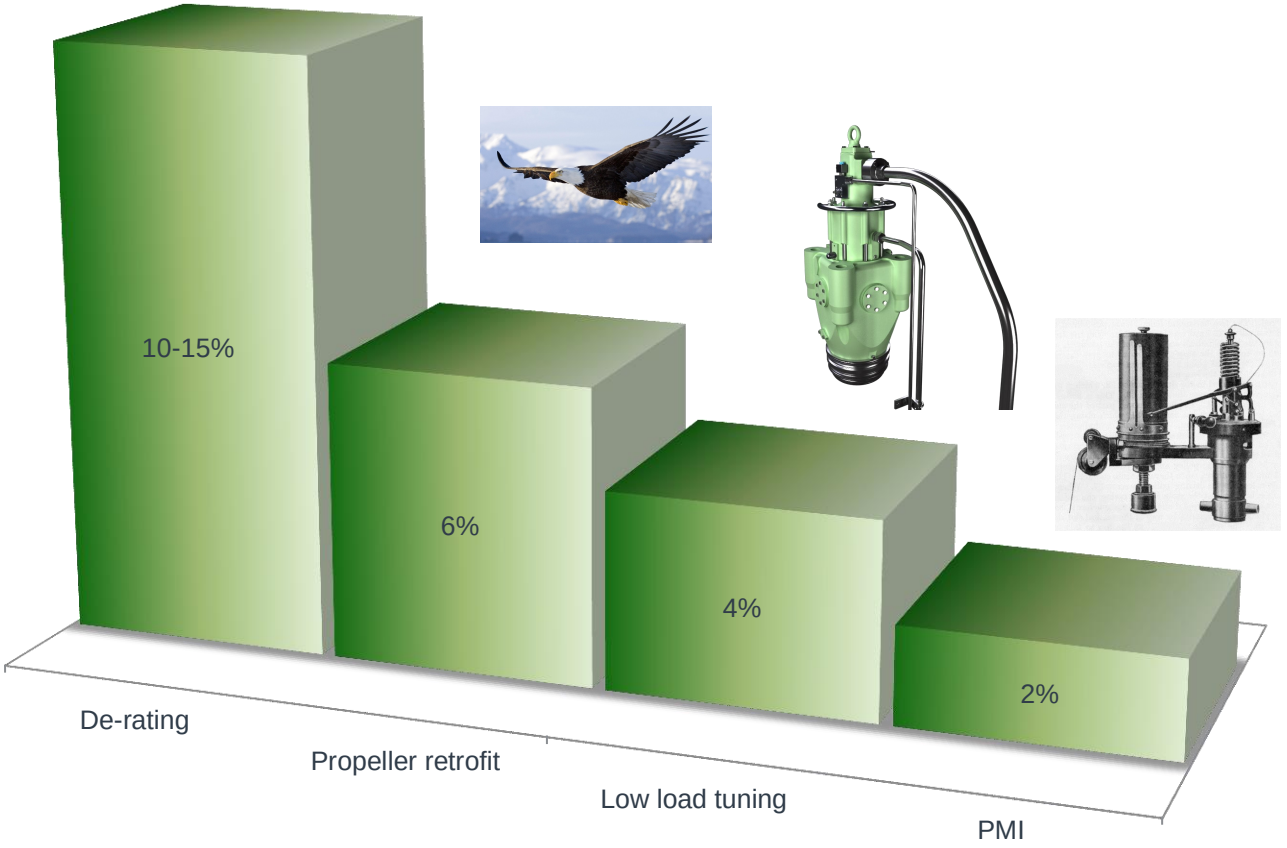
Give your MC a little E

High eficiency Kappel propeller

High eficiency Kappel propeller

Fuel savings

Fuel Savings



Fuel savings

a lot of

HOW DO WE SAVE FUEL?

Fuel savings

HOW DO WE SAVE FUEL?

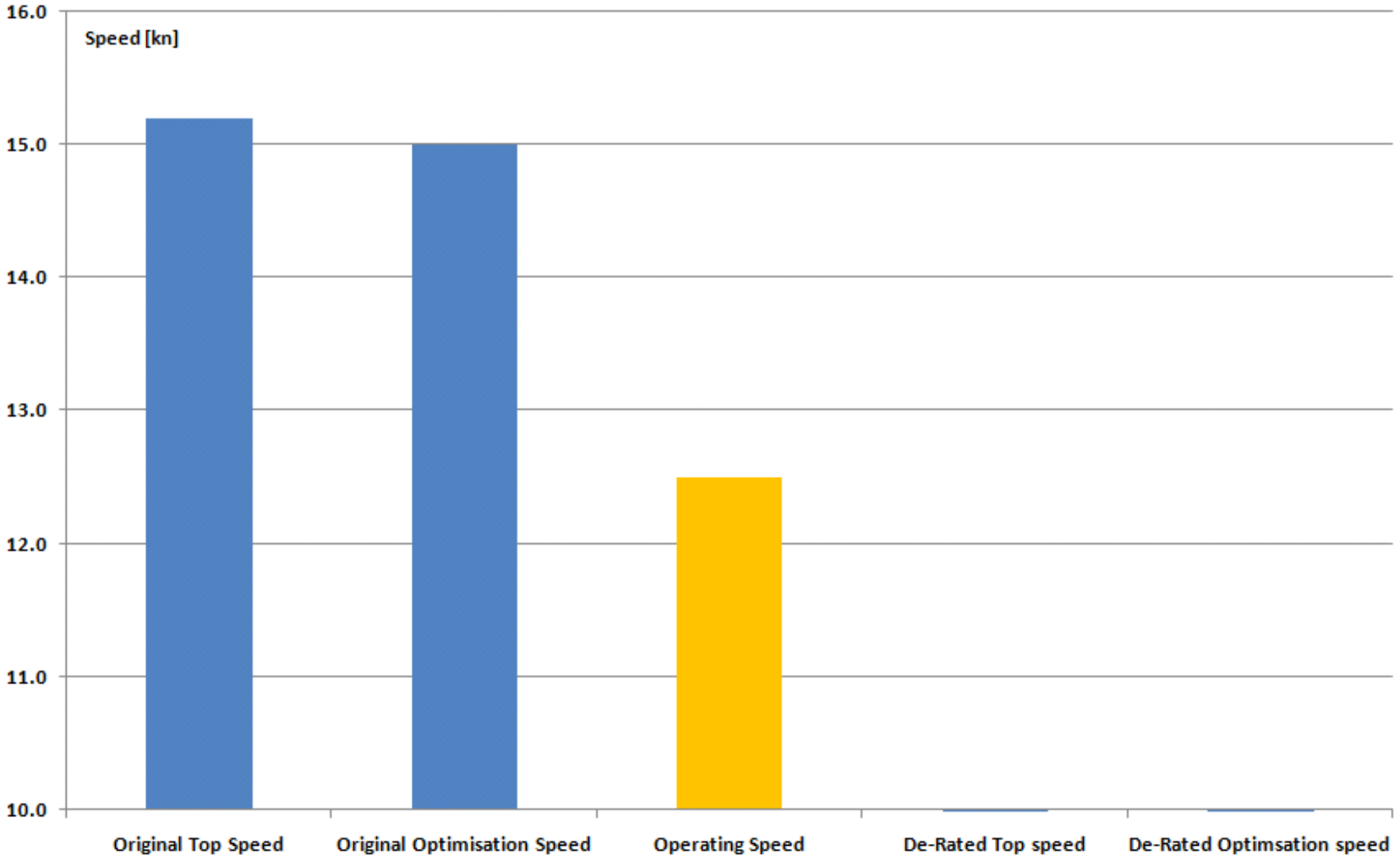
DE-RATING

De-rating potential

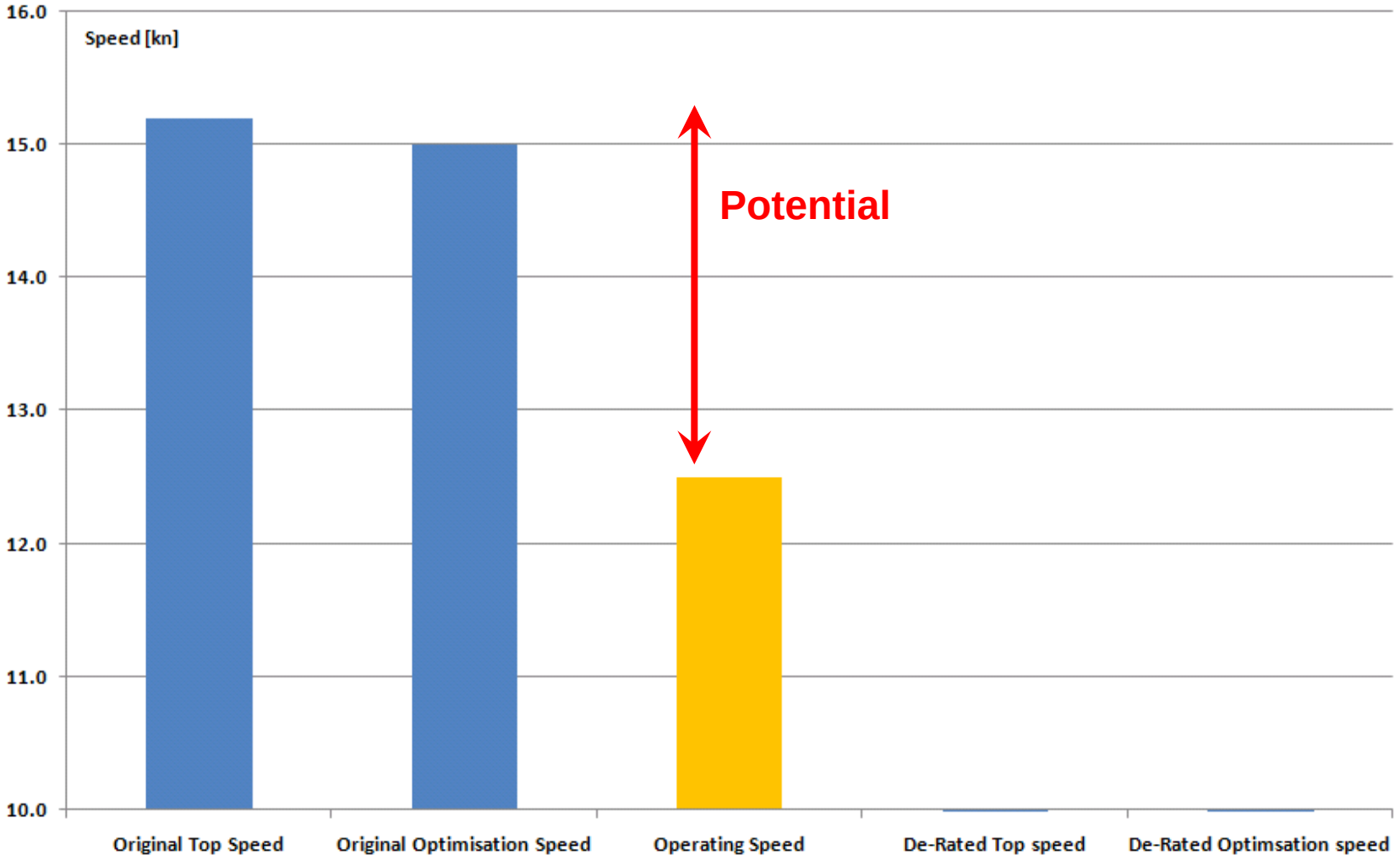
Saving potential: 10-15%

Cost estimate: 1-3 mill EUR

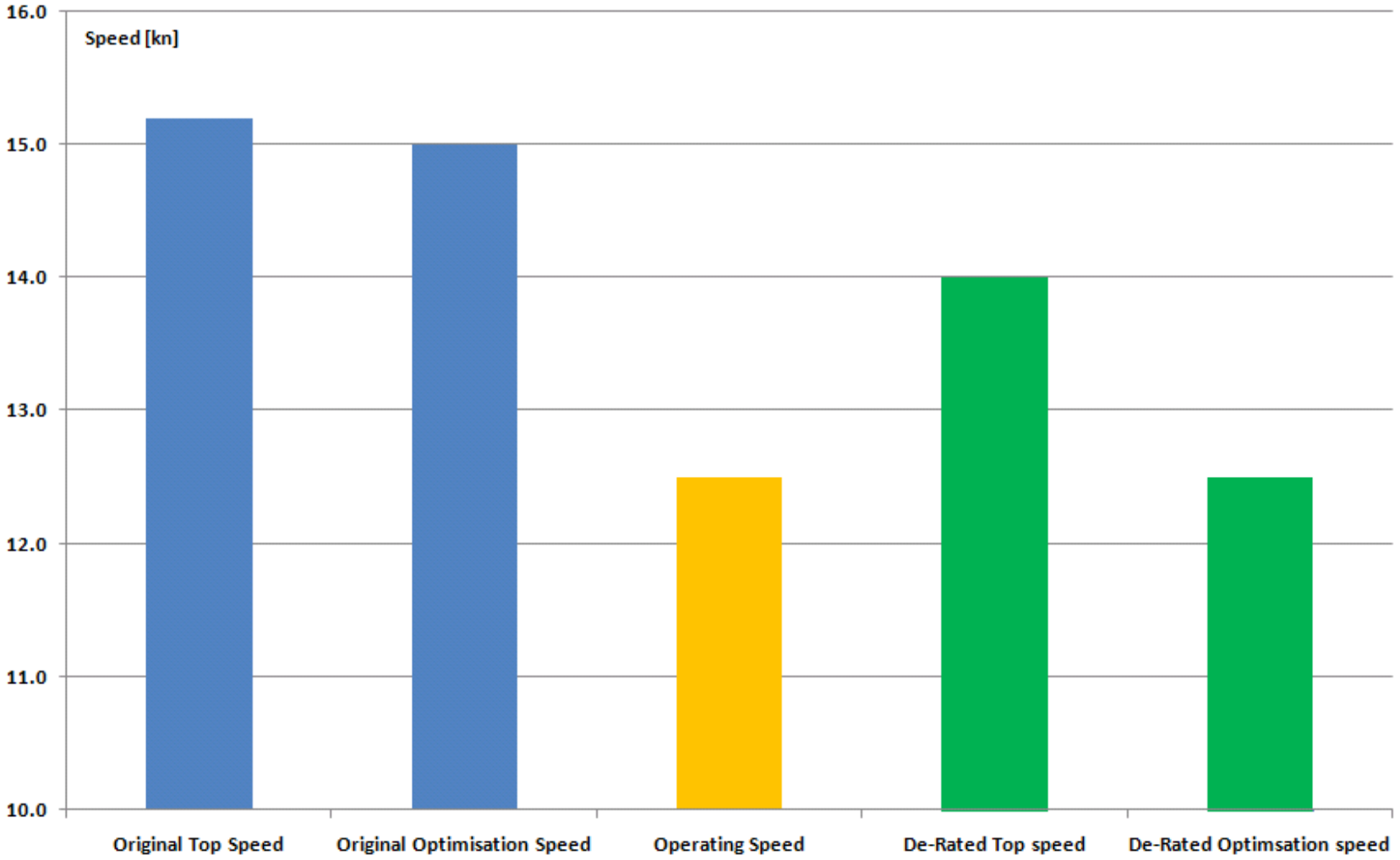
De-rating potential



De-rating potential

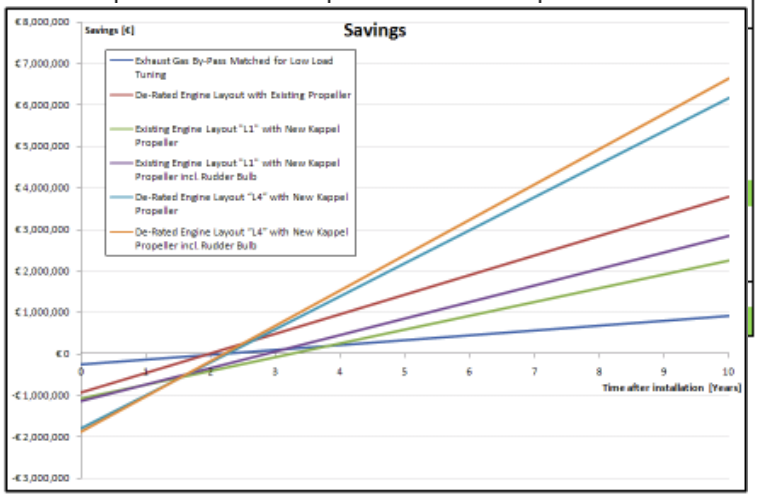


De-rating potential

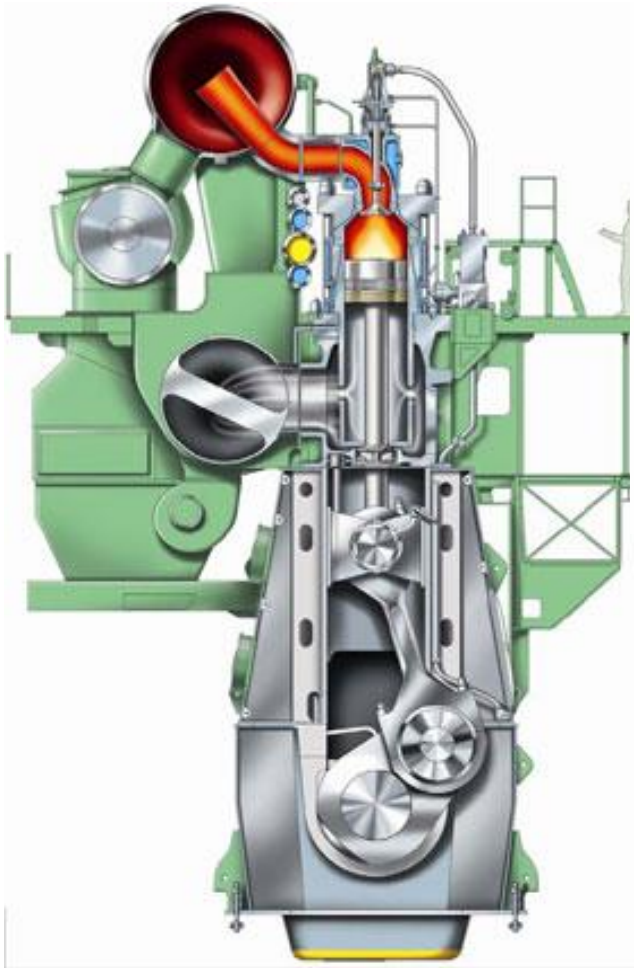


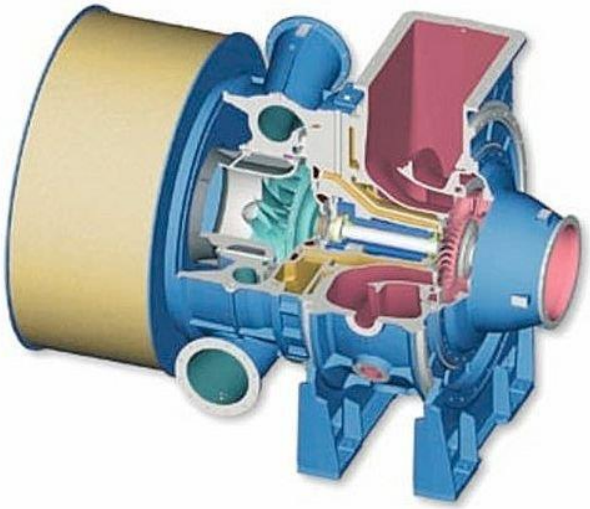
Vessel and engine specific study

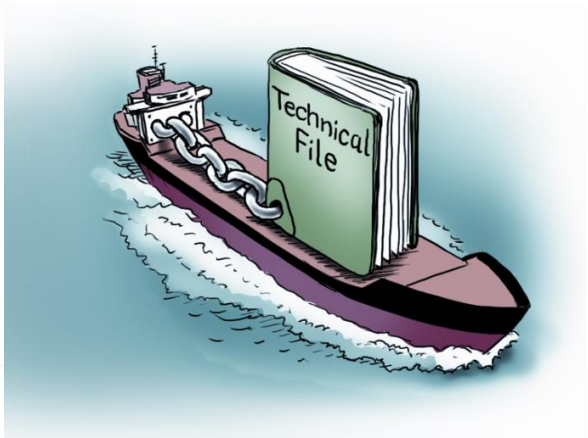
Solution	A	B	C	D	E	F
		De-Rated Engine Layout with Existing Propeller	Existing Engine Layout "L1" with New Kappel Propeller	Existing Engine Layout "L1" with New Kappel Propeller incl. Rudder Bulb	De-Rated Engine Layout "L4" with New Kappel Propeller	De-Rated Engine Layout "L4" with New Kappel Propeller incl. Rudder Bulb
Cost						
Engineering		185,263	€ 12,363	€ 12,363	€ 185,263	€ 185,263
Engine					€ 16,911	€ 16,911
Exhaust Gas By-Pass			€ 53,718	€ 53,718	€ 53,718	€ 53,718
Turbocharger			€ 150,000	€ 150,000	€ 500,845	€ 500,845
TVC damper					€ 226,917	€ 226,917
Propeller on Exchange Basis		e Used	€ 806,880	€ 877,220	€ 647,500	€ 717,840
Scrap Value:			-€ 349,580	-€ 349,580	-€ 349,580	-€ 349,580
Installation on board		3,170	€ 35,200	€ 35,200	€ 158,170	€ 158,170
Sea Trial Attendance		10,640	€ 10,640	€ 10,640	€ 10,640	€ 10,640
Cost per Vessel		**€ 925,547**	**€ 1,068,801**	**€ 1,139,141**	**€ 1,799,964**	**€ 1,870,304**
Additional Cost fr		€ 232,378	€ 31,990	€ 39,810	€ 219,608	€ 227,428
Savings						
FOC		3.500	2.			
		2.624	1.			
		3.539	3.			
		3.489	2.			
		7.1				
		610,507	**43**			
Pay Back						
12.5		**2.0**				



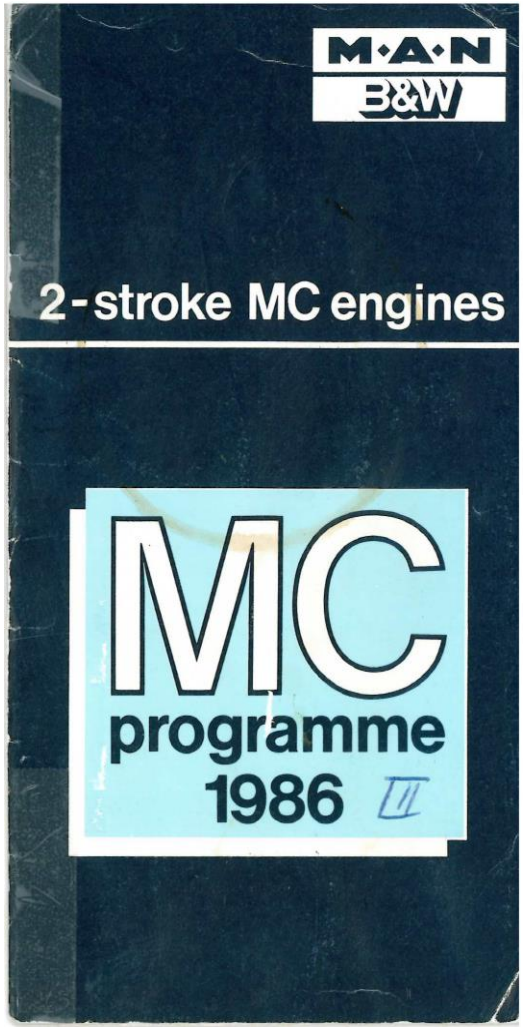
De-rating project





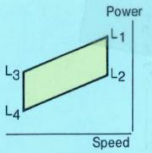


De-rating of the engine



Power, Speed and SFOC

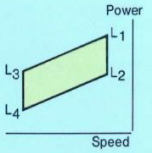
K90



		K90MC Stroke: 2550 Bore: 900				K90MCE Stroke: 2550 Bore: 900			
		L_1	L_2	L_3	L_4	L_1	L_2	L_3	L_4
Speed r/min		90	90	67	67	90	90	67	67
Cyl.no.	Power								
4	kW	15760	12640	11720	9400	12640	10120	9400	7520
	BHP	21440	17200	15960	12800	17200	13760	12800	10240
5	kW	19700	15800	14650	11750	15800	12650	11750	9400
	BHP	26800	21500	19950	16000	21500	17200	16000	12800
6	kW	23640	18960	17580	14100	18960	15180	14100	11280
	BHP	32160	25800	23940	19200	25800	20640	19200	15360
7	kW	27580	22120	20510	16450	22120	17710	16450	13160
	BHP	37520	30100	27930	22400	30100	24080	22400	17920
8	kW	31520	25280	23440	18800	25280	20240	18800	15040
	BHP	42880	34400	31920	25600	34400	27520	25600	20480
9	kW	35460	28440	26370	21150	28440	22770	21150	16920
	BHP	48240	38700	35910	28800	38700	30960	28800	23040
10	kW	39400	31600	29300	23500	31600	25300	23500	18800
	BHP	53600	43000	39900	32000	43000	34400	32000	25600
11	kW	43340	34760	32230	25850	34760	27830	25850	20680
	BHP	58960	47300	43890	35200	47300	37840	35200	28160
12	kW	47280	37920	35160	28200	37920	30360	28200	22560
	BHP	64320	51600	47880	38400	51600	41280	38400	30720
SFOC g/BHPh at MCR									
With TCS		121	118	121	118	118	115	118	115
Without TCS		126	121	126	121	121	117	121	117
SFOC g/BHPh minimum at part load									
With TCS		120	117	120	117	117	114	117	114
Without TCS		124	119	124	119	119	116	119	116
Lube Oil Consumption		10-13 kg/cyl/24 h							
Cylinder Oil Consumption		0.6 g/BHPh							

Power, Speed and SFOC

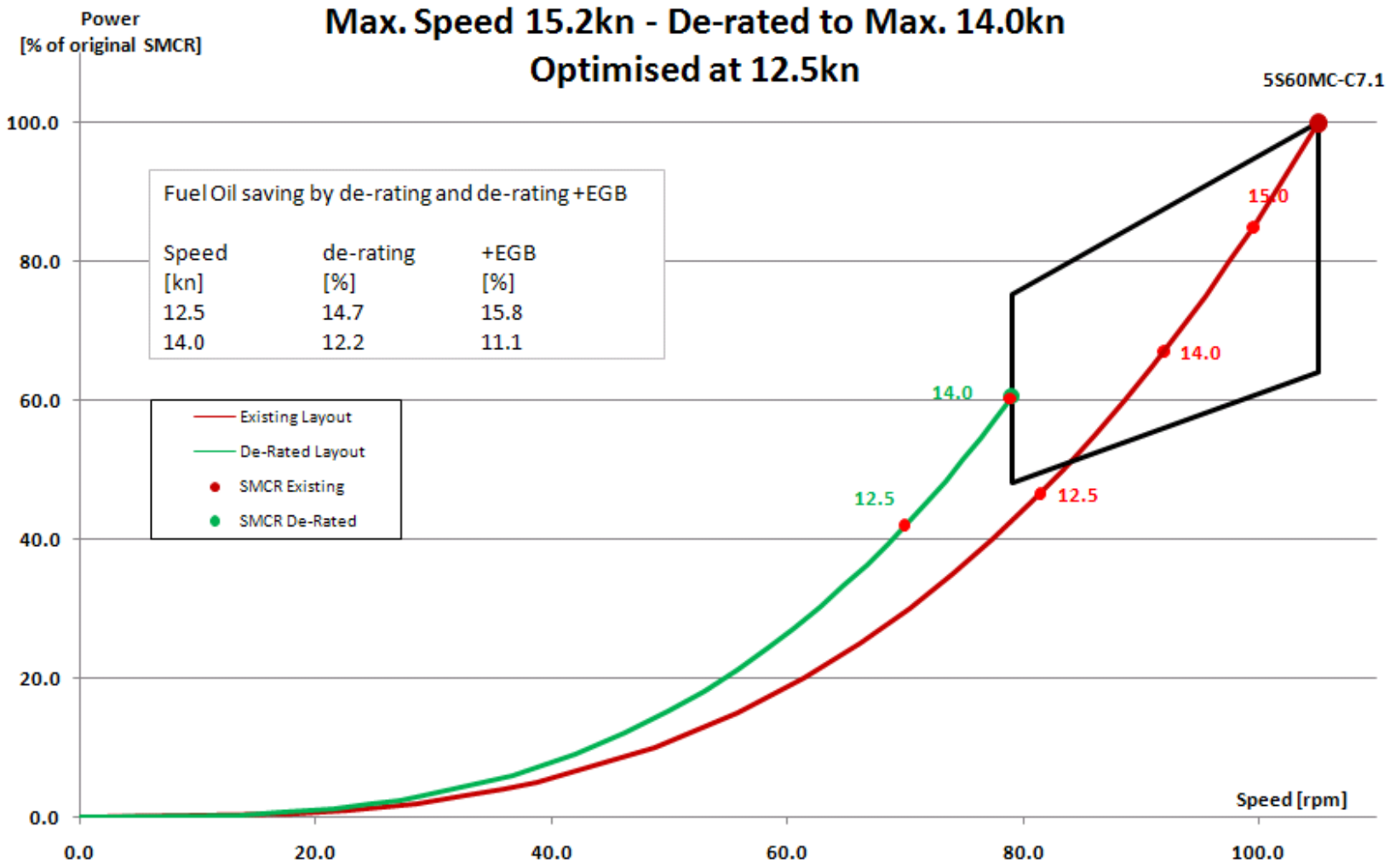
L90



		L90MC Stroke: 2916 Bore: 900				L90MCE Stroke: 2916 Bore: 900			
		L_1	L_2	L_3	L_4	L_1	L_2	L_3	L_4
Speed r/min		78	78	58	58	78	78	58	58
Cyl.no.	Power								
4	kW	15640	12560	11640	9320	12560	10040	9320	7440
	BHP	21240	17040	15800	12680	17040	13640	12680	10160
5	kW	19550	15700	14550	11650	15700	12550	11650	9300
	BHP	26550	21300	19750	15850	21300	17050	15850	12700
6	kW	23460	18840	17460	13980	18840	15060	13980	11160
	BHP	31860	25560	23700	19020	25560	20460	19020	15240
7	kW	27370	21980	20370	16310	21980	17570	16310	13020
	BHP	37170	29820	27650	22190	29820	23870	22190	17760
8	kW	31280	25120	23280	18640	25120	20080	18640	14880
	BHP	42480	34080	31600	25360	34080	27280	25360	20320
9	kW	35190	28260	26190	20970	28260	22590	20970	16740
	BHP	47790	38340	35550	28530	38340	30690	28530	22860
10	kW	39100	31400	29100	23300	31400	25100	23300	18600
	BHP	53100	42600	39500	31700	42600	34100	31700	25400
11	kW	43010	34540	32010	25630	34540	27610	25630	20460
	BHP	58410	46860	43450	34870	46860	37510	34870	27940
12	kW	46920	37680	34920	27960	37680	30120	27960	22320
	BHP	63720	51120	47400	38040	51120	40920	38040	30480
SFOC g/BHPh at MCR									
With TCS		121	118	121	118	118	115	118	115
Without TCS		126	121	126	121	121	117	121	117
SFOC g/BHPh minimum at part load									
With TCS		120	117	120	117	117	114	117	114
Without TCS		124	119	124	119	119	116	119	116
Lube Oil Consumption		10-13 kg/cyl/24 h							
Cylinder Oil Consumption		0.6 g/BHPh							

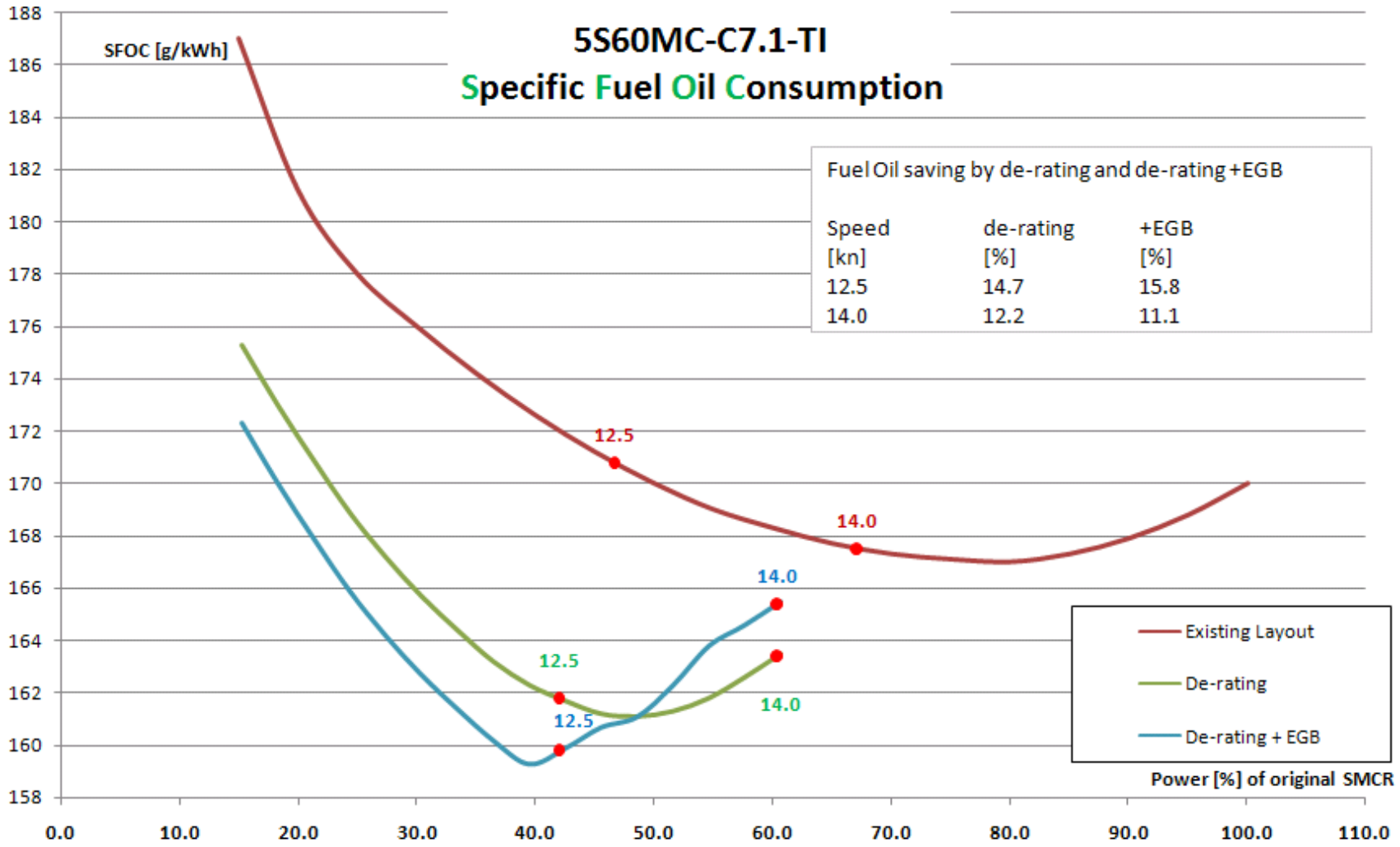
Case study

Panamax Tanker



Case study

Panamax Tanker



Fuel Oil saving by de-rating and de-rating +EGB

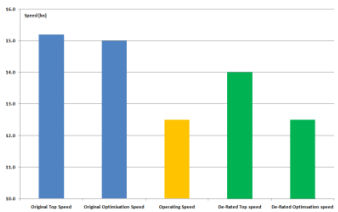
Speed [kn]	de-rating [%]	+EGB [%]
12.5	14.7	15.8
14.0	12.2	11.1

Case study

Panamax Tanker

Panamax tanker, 74K DWT

	Existing setup	De-rated setup
Max speed (kn)	15,2	14,0
Optimising speed	15,0	12,5
Operating speed	12,5	12,5
SMCR (kW)	11.300	6.850
RPM	105	79



Saving potential: 12-15%
Cost estimate: EUR 1,2 mill
Payback: 2,5 years

Alternative fuel

Alpha Lub

Slide valves

PMI Auto tuning

Low load tuning

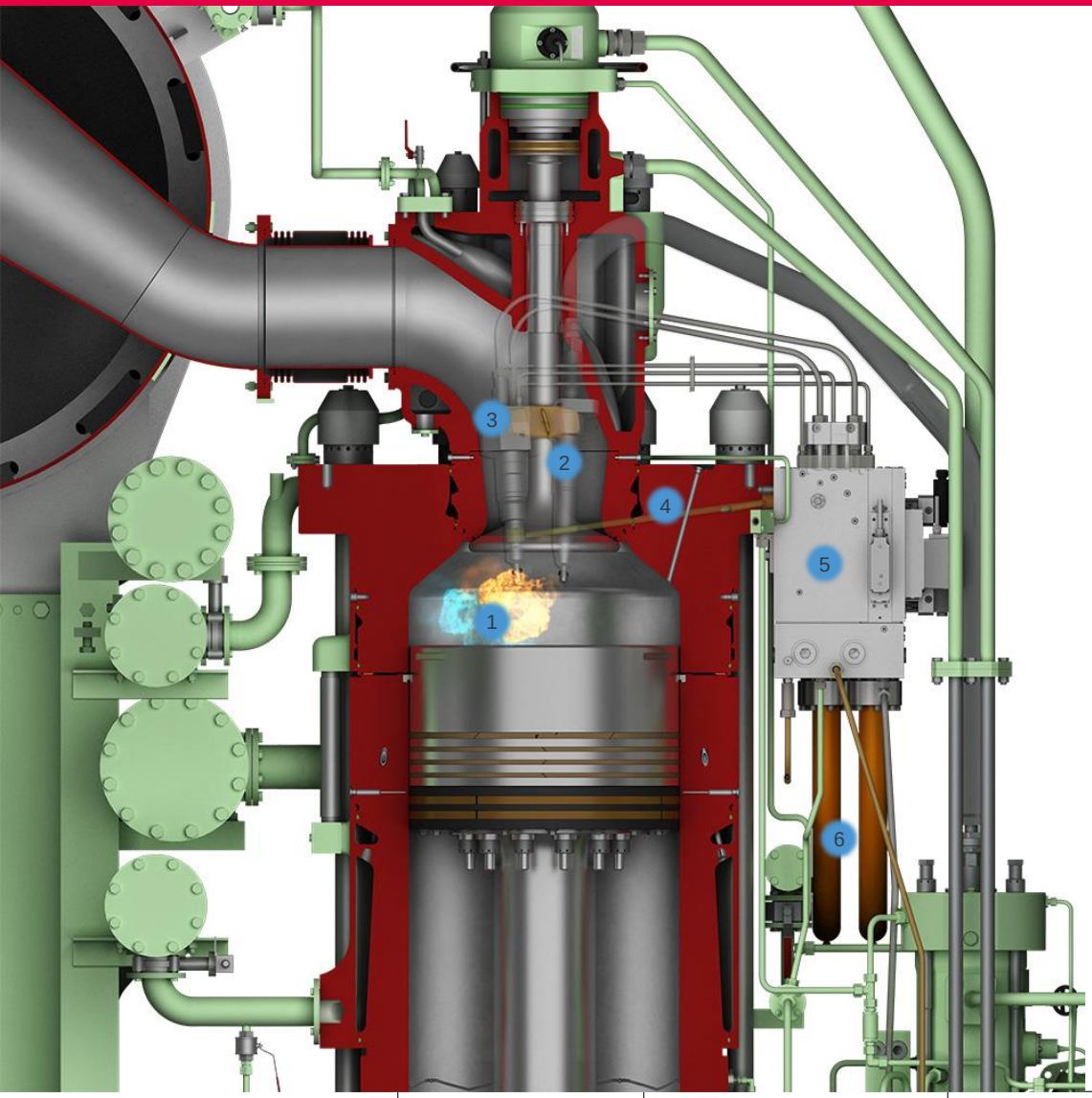
Propeller optimization

De-rating

Gas conversion ME-GI

ME-GI

Combustion concept

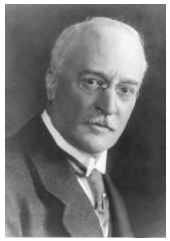


1. From actual footage (colorized)

   Yellow = pilot oil
   Blue = gas fuel

2. Conventional slide fuel valve
3. Gas fuel valve
4. Gss distribution channel (yellow)
5. Gas distributor block
6. Gas chain link double-walled pipes

ME-GI



Mr. Diesel's Process

(High Pressure Injection)

- Fuel in cylinder before gas
- Diesel process maintained
- Power remain the same
- Load response unchanged
- No pre-ignition / no knocking
- Insensitive to gas mixture
- Negligible methane slip
- High-pressure gas injection
- NO_x reduction to Tier III level by EGR and / or SCR

ME can be retrofit to ME-GI.

Mr. Otto's Process

(Low pressure Injection)

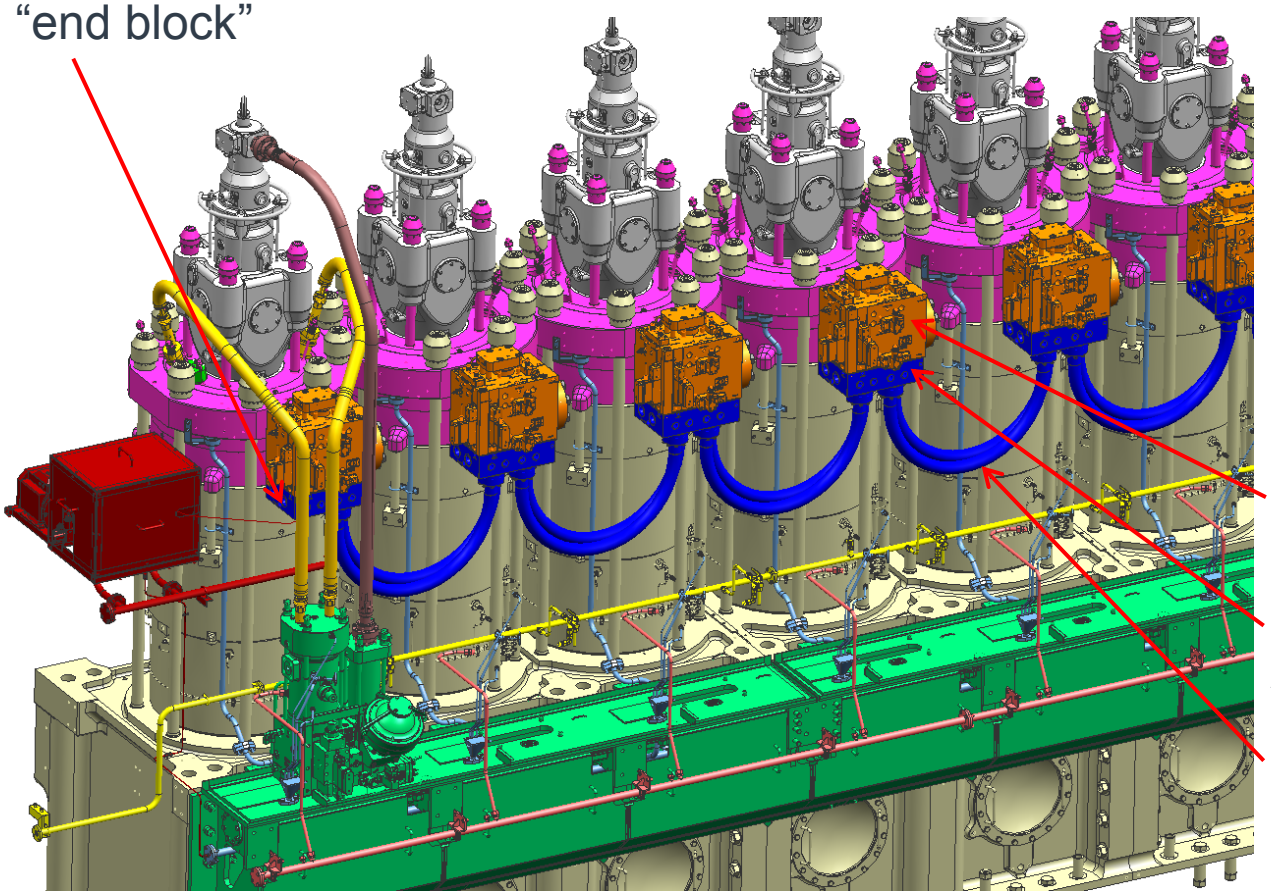
- Gas in cylinder before fuel
- Otto process gas-air pre-mix
- ***Power reduction*** required due to
- ***Pre-ignition / knocking*** risk
- ***Load ramp*** needed
- ***Gas mixture*** important
- ***Methane slip*** significant
- Low-pressure gas injection
- Lower NO_x due to ***low efficiency.***
- Can ***only*** be ***retrofit*** if ***excess capacity*** is installed initially (20% larger engine, 20% greater fuel tanks, etc

ME-GI is a Two-stroke ***Diesel*** Engine

From ME to ME-GI

Gas block and pipes on engine

Unit #1 adaptor block is an "end block"



Gas supply line and vent line looped from unit to unit

Gas control block

Adaptor block

Gas pipes

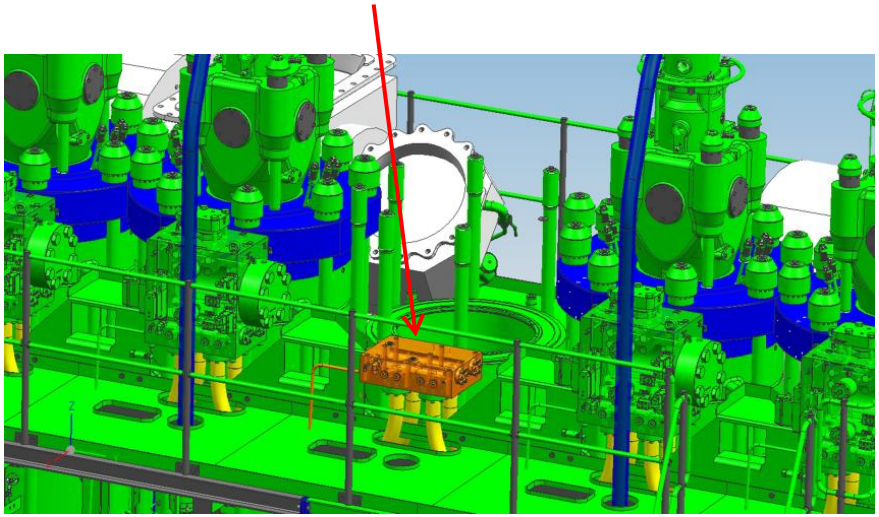
ME-GI

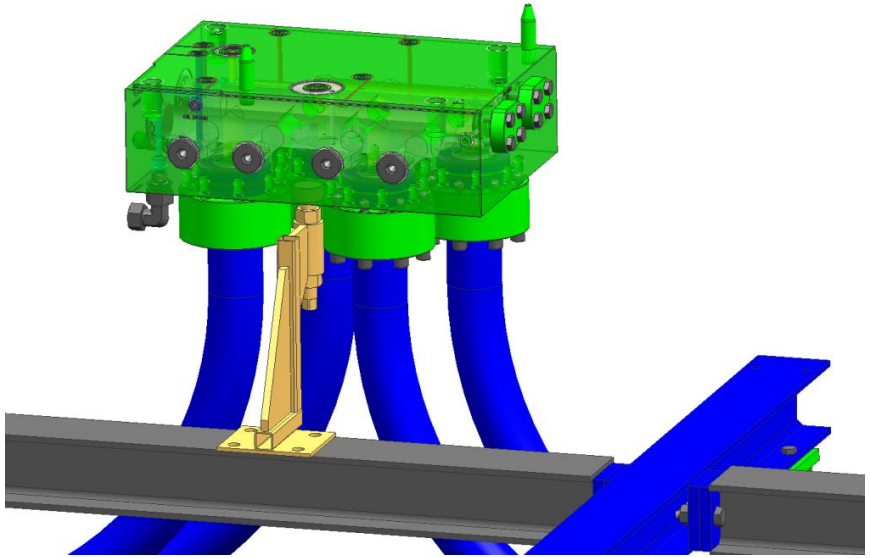
Adaptor block

At cylinder cover lift, the gas control block is dismantled from the adaptor block by 4 bolts. The gas control block is removed with the cylinder cover, the adaptor block with all pipe connections stays in place.

➢ **= No risk of faulty pipe assembly.**

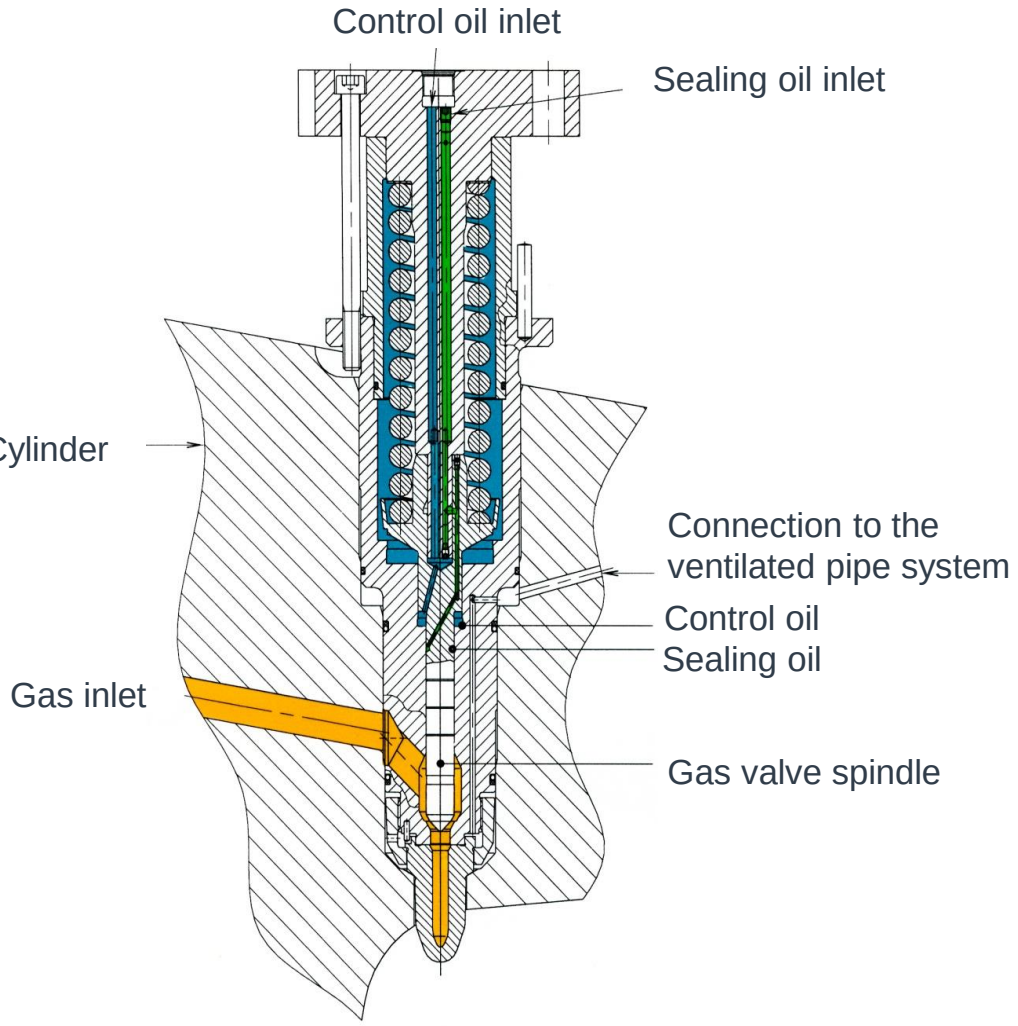
Adaptor block with pipes, remains the on engine at cylinder cover removal.





ME-GI

Gas injection valve



Scope of Supply – from MC or ME to ME-GI engine retrofit

ME / ME-C / MC / MC-C engines	Additional for MC / MC-C engines
Cylinder covers	Hydraulic system
Gas Control Block complete	• Pump station
Gas injector valves	• Supply pipe
Sealing oil unit	• Automatic fine filter unit
Control- and sealing oil pipes	Hydraulic Cylinder Unit (HCU)
Modification to the engine hydraulic system	Fuel booster incl. actuator
Modifications for exhaust valves	Modifications for exhaust valves
Atomizers for fuel injector valves	ME-B Control system
Fuel oil high pressure pipes	Tacho system at flywheel and fore end
Gas pipe arrangement on engines	Alpha cylinder lubrication system
Control and safety system (GI-ECS)	

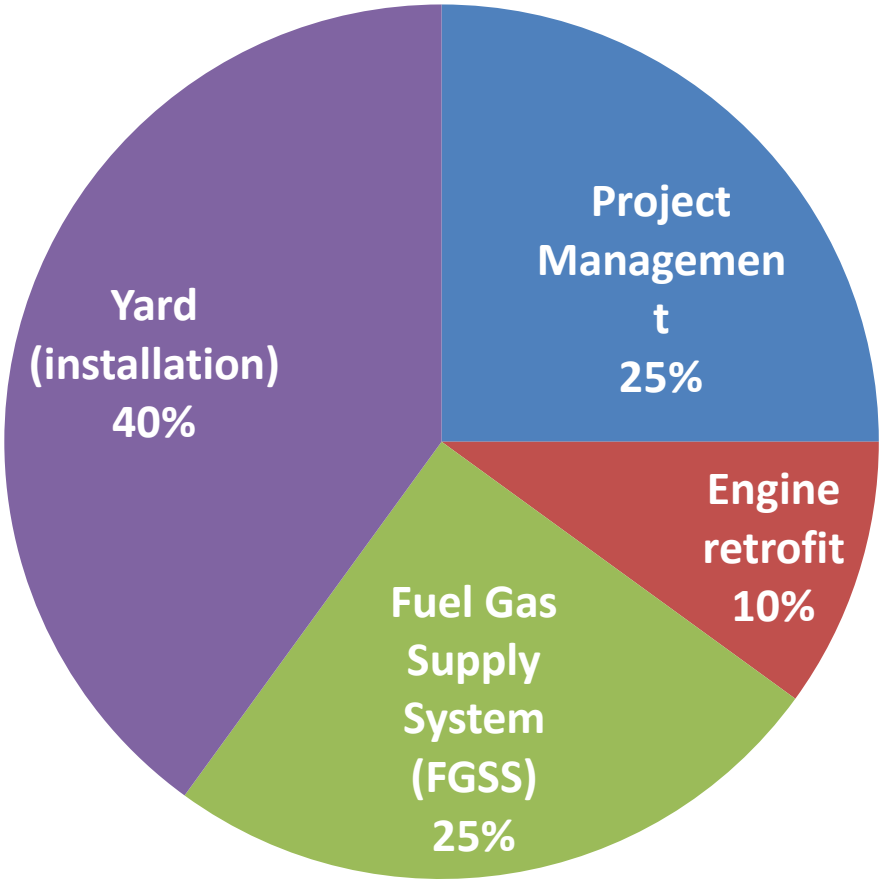
Out of Scope of Supply, ME-GI retrofit

ME / ME-C / MC / MC-C engines
Inert gas system for flushing the gas system
Double pipe system in the engine room
Block and bleed valve systems
Silencer for gas venting
Fuel Gas Supply System (FGSS)
LNG tank systems
LNG bunkering systems
Gas detection system
Fire fighting systems

Indicative budget prices for modification of Engines

Bore	Engine type	Indicative budget price [EUR]	
		Components	Installation
50	6S50ME / ME-C	825.000	300.000
	6S50MC / MC-C	1.800.000	500.000
60	6S60ME / ME-C	830.000	300.000
	6S60MC / MC-C	1.900.000	500.000
70	6S70ME / ME-C	870.000	300.000
	6S70MC / MC-C	1.960.000	500.000
80	6K80ME / ME-C	1.120.000	300.000
	6K80MC / MC-C	1.630.000	500.000
90	6S90ME / ME-C	1.060.000	300.000
	6S90MC / MC-C	1.750.000	500.000
98	12K98ME / ME-C	2.000.000	600.000
	12K98MC / MC-C	3.600.000	1.000.000

Example of cost split, ME to ME-GI retrofit



Project Management includes:

Class & document handling, QHSE, HAZID/HAZOP, external consultants

Yard includes:

Installation, hull work, aux systems, piping/structural engineering, cabling, etc

ME-GI conversion Project

Stage-Gate model

Gate 0 – Customer request

1 Define

- Specify vessel(s)
- LNG tanks
- Boil Off Gas treatment
- Fuel Gas Supply System
- Price estimation
- Project organisation structure
- Initial timeline
- Project description
- Indicative budget price
- Define main project lead
- Project organisation ready for stage 2 + 3
- Project plan up to contract signature
- Pre engineering contract

Gate 1 – Pre engineering contract

2 Pre engineering

- Pre engineering engine
- Pre engineering FGSS
- Pre engineering installation
- HAZID workshop
- Class involvement
- Class Approval in Principle
- FGSS detailed spec
- Installation detailed spec
- Large Project Approval
- Tender submission

Gate 2 – Commitment – LOI

3 Contracts and tools

- Evaluation of incoming bids
- Work Breakdown Structure
- Risk Analysis
- Project Execution Plan
- Project timeline
- Contract negotiations
- Sub supplier selection
- Project Management tools ready
- Contracts ready to sign

Gate 3 – Contract

4 Execute

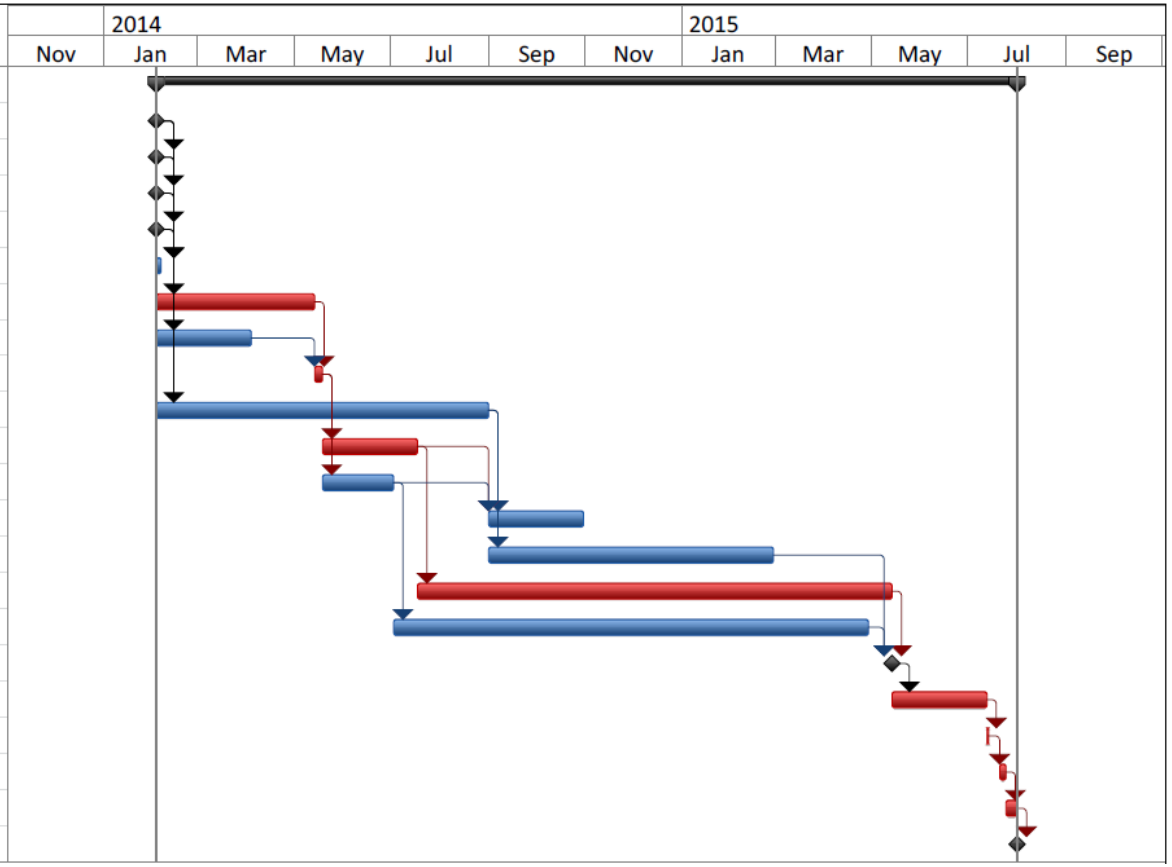
Stage 2 - Pre engineering

Main topics for project specific pre engineering:

- Define hazardous areas onboard
- Gas venting policy (venting in emergency case)
- Fire detection / fighting systems
- HC detection systems
- Define engine modifications e.g. updated combustion chamber design, piping, cabling
- Define LNG tank system incl. position onboard
- Define Fuel Gas Supply System (FGSS) incl. position onboard
- Gas pipe routing on deck (personnel safety, heavy lifting, etc.)
- Gas pipe routing in engine room (personnel safety, heavy lifting, etc.)
- HAZID workshop
- Integration with existing alarm & monitoring system
- Safety valves in system

Typical Timeframe
(based on LNG FGSS)

ID	Task Mode	Task Name	Duration
1		**ME-GI conversion main tasks**	**544 days**
2		Project start	0 days
3		Supplier agreement Engine Parts	0 days
4		Supplier agreement FGSS	0 days
5		Supplier agreement Yard	0 days
6		Kick-Off meeting	3 days
7		Basic Engineering FGSS	100 days
8		Basic Engineering Yard installation	60 days
9		HAZOP	5 days
10		Engineering engine components	210 days
11		Detailed design FGSS	60 days
12		Detailed design Yard installation	45 days
13		FMEA	60 days
14		Engine parts manufacturing	180 days
15		FGSS manufacturing	300 days
16		Yard prefabrication	300 days
17		Vessel Arrival at Yard	0 days
18		Docking period conversion	60 days
19		Sea Trial	1 day
20		Loading of Gas	4 days
21		Gas Trial	7 days
22		Project finish	0 days



Dual fuel gas engine – Tier II Reference list

Engine type ME-GI / ME-LGI

No. of ships	Opt.	No. of eng.	Engine	Mk	Gas	Ship Type	Capacity	Unit	Owner	Builder	Yard	Hull no.	Delivery year
5	5	**20**	5 G 70 ME-C	9.2	**GI**	LNG tankers	173400	CBM	Teekay LNG partners	Hyundai	DSME	DW2407/08/16/17 #1+2	2014
2	3	**5**	8 L 70 ME-C	8.2	**GI**	Container	3100	Teu	Totem Ocean Trailer	Doosan	NASSCO	TOTE6495/96	2014
2	9	**15**	9 L 28/32 DF **Gensets**										
2	2	**4**	7 S 90 ME-C	9.2	**GI**	Container	3600	Teu	Matson	Hyundai	Aker Philadelphia	029/ 030	2018
2	2	**4**	8 S 50 ME-B	9.3	**GI**	Container	1431	Teu	Brodosplit	Brodosplit	Brodosplit		2015
2		**4**	7 G 70 ME-C	9.2	**GI**	LNG tankers	176300	CBM	Knutsen OAS Shipping	Hyundai	HHI-SBD		2015
2	1	**3**	6 G 50 ME-B	9.3	**LGI**	Methanol Carrier	50000	dwt	Westfal-Larsen	Hyundai	HMD		2015
2	1	**3**	6 G 50 ME-B	9.3	**LGI**	Methanol Carrier	50000	dwt	Marinvest	Hyundai	HMD		2015
2	1	**3**	7 S 50 ME-B	9.3	**LGI**	Methanol Carrier	50000	dwt	MOL	Mitsui	MNS		2015

Total Dual Fuel main engine **46** engines

Total Dual Fuel Gensets **15** Gensets

Total power main engine **924** MW

Two stroke retrofit

Alpha Lub

Slide valves

PMI Auto tuning

Low load tuning

Propeller optimization

De-rating

Gas conversion ME-GI

Thank you for your attention

All data provided in this document is non-binding. This data serves informational purposes only and is especially not guaranteed in any way. Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.